::ODMA\MHODMA\iManage;173814;1
WP9.0
RTC/ELE
November 29, 2000

PATENT APPLICATION
Docket No. 1571.2001-002

Date: November 29, 2000 Express Mail Label No. EL551544773US

Inventors: James F. Munro and John A. Futhey

Attorney's Docket No.: 1571.2001-002

ASYMMETRIC ALTERNATING PRISM ARRAYS

RELATED APPLICATIONS

This application claims the benefit of U.S. Application No. 60/208,339, filed May 31, 2000, and U.S. Application No. 60/168,586, filed on December 2, 1999, the entire teachings of the above applications are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Luminaires typically include a lighting source, a waveguide, and microprisms used to redirect the light in a desired direction. These luminaires are used to provide a more uniform light distribution than conventional light systems and alleviate glare in applications such as office space, boardrooms, and customer service centers.

SUMMARY OF THE INVENTION

Sub A'7

A luminaire is provided which includes a light source, a light guide that receives light radiating from the light source, and a plurality of tilted prism arrays for redirecting the light in a first direction. In one embodiment, the plurality of prism arrays, which can include linear prisms, periodically alternate orientation along the light guide. The linear prisms can have included angles of 25, 90, and 65 degrees. The prism arrays can alternate or flip-flop in orientation every few millimeters, for example, one to two millimeters. A tilted prism can have sides on each side of the peak with a first length from the valley to the peak on one side and a second length from the valley to the peak

Sub A1 cont

on a second side of the prism, where the first length is different in length from the second length, thereby tilting or canting the prisms. The tilting angle of the prisms is between the optical axis and a line perpendicular to the window side. The tilting angle can be in the range between about 20 and 70 degrees.

Sub B2

The prism arrays can include peaks and valleys along a first axis. The prism arrays can also include peaks and valleys along a second axis different than the first axis, such as substantially perpendicular or offset about 60 degrees relative to the first axis. The prism arrays can further include peaks and valleys along a third axis that is different than the second axis and the first axis. In one embodiment, the third axis is offset about 60 degrees relative to the second axis. The plurality of prism arrays can be disposed on a top surface of the light guide.

Sub A2

An optical microstructure is also provided which includes a plurality of tilted prism arrays that periodically alternate orientation of the tilted prism arrays along a first axis. The prism arrays can also periodically alternate orientation along a second axis and, in alternative embodiments, along a third axis. The optical microstructure can be disposed on a first surface of a film. A plurality of prism arrays can be disposed on a second surface of the film. The plurality of prism arrays on the second surface can be tilted and periodically alternate orientation along at least one axis. The purpose of the periodic alternate orientation of the prism angles is to create alternating bands of bright and dark lines which can be seen viewing the surface of the luminaire. Very small or fine pitch prisms that are not visible to the human eye beyond 0.5 meters can be made to look like macro prisms because of the visibility of the bright and dark bands. Low cost manufacturing concepts, such as continuous casting, can be used to form the precision fine pitch alternating prism groups and achieve the appearance of a precision macro prism, for example, 0.508 to 2.54 mm (0.02 to 0.1 inch) pitch, which would normally be made with a more expensive manufacturing concept, such as compression molding.

Sub A3

Multi-faceted prisms can be used, for example, prisms that have more than one slope on a facet. Further, prisms can be used which have curved facets or curved prisms tips and valleys. These features are used to smooth the resulting light distribution.

Sub A4

A method for redirecting light is also provided which includes providing a light source, receiving light radiating from the light source in a light guide, and redirecting the light in a first direction with a plurality of tilted prism arrays that periodically alternate orientation along a first axis. The plurality of tilted prism arrays can periodically alternate orientation along a second axis different than the first axis. The plurality of tilted prism arrays can further periodically alternate orientation along a third axis which is different than the second axis.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

Figure 1 is a partial cross-sectional view of a waveguide for use in a display apparatus particularly illustrating linear prisms arranged in accordance with the present invention.

Figure 2 is a cross-sectional view of a luminaire employing waveguide of Figure 1.

Figure 3 is a cross-sectional view of a pair of waveguides which receive and direct light from a light source substantially downward.

Figure 4 is a graph illustrating light output of an exemplary backlit display apparatus at an observation or viewing angle range of about -90° to +90°.

Figure 5 are graphs illustrating light output of an exemplary backlit display apparatus at viewing range of about -70° to +70°.

Figure 6 is a cross-sectional view of an alternative embodiment of a luminaire in accordance with the present invention.

Figure 7 illustrates photometric data from the luminaire of Figure 6.

Figure 8 is a cross-sectional view of another embodiment of a luminaire in accordance with the present invention.

Figure 9 is a cross-sectional view of yet another embodiment of a luminaire in accordance with the present invention.

Figure 10 is a cross-sectional view taken along line 10-10 of Figure 6.

Figure 11 is an enlarged view of the prisms shown in Figure 6.

and A4

DETAILED DESCRIPTION OF THE INVENTION

A description of preferred embodiments of the invention follows. Generally, the invention is directed to a backlit display apparatus ("BLDA") having a coarse appearance. An example of a BLDA is disclosed in U.S. Patent 5,629,784, issued to Abileah *et al.* on May 13, 1997, the teachings of which are incorporated herein in its entirety by reference.

Sub B1

Figure 1 is a partial cross-sectional view of a waveguide or light guide 10 for use in a BLDA particularly illustrating the linear prisms 12. The prism angles, in one embodiment, are 25°-90°-65° (90° is the peak angle with a first side of the prism is 25° from the horizontal to peak and a second side of the prism is 65° from the horizontal to the peak). The pitch, or tip to tip spacing, in one embodiment, is in the range from about 0.0508 to 0.254 mm (0.002 to 0.01 inches). The tilting angle, as measured from the peak angle, can be in the range between about 20 and 70 degrees. The prism arrays preferably alternate or flip-flop in orientation, i.e., they are mirror images with respect to line L. In one embodiment, the prism arrays flip-flop every few millimeters, for example, one to two millimeters.

Sub A5

The waveguide 10 can be solid being formed from a material such as polymethyl methacrylate (PMMA) or other suitable materials. In alternative embodiments, any of the prisms disclosed herein can be used with hollow waveguides in any of the embodiments as disclosed in U.S. Application No. ______, Attorney's Docket No. 1571.1140-001, filed on even date herewith, the contents of which are incorporated herein by reference.

When viewed from below, one set of fine pitch prisms 12 is generally oriented to reflect light towards the viewer, and the neighboring pair away from the viewer. Thus, the viewer sees a set of alternating bright and dark lines, which can be referred to as a coarse appearance. It is understood that the number of prisms 12 within a prism grouping is variable, which means that the width of a group and its coarseness can be easily controlled.

Figure 2 illustrates a luminaire 8 having an exemplary waveguide 10 coupled to a light source 14, such as a fluorescent cylindrical bulb. A viewer at point X sees the center group of prisms 12 as brighter because they direct light from the source 14 to point X. Since the light from adjacent prism groups is directed elsewhere, these groups appear dark. At point Y, the center group can appear dark, and the adjacent groups are brighter. At some point between X and Y, the groups appear to be equal in brightness. Further, the output light distribution is such that the image of the light source 14, such as a cylindrical bulb, is masked. It is noted that the prisms 12 of Figure 2 are substantially enlarged for illustrative purposes only.

Figure 3 illustrates a luminaire 9 having a pair of waveguides 10 which receive and direct light from source 14 substantially downward. A reflective coating 16, such as vacuum metalized aluminum or metalized polyester (PET) or polished aluminum, is provided on the top and end surfaces of the waveguide 10 to allow the light rays to be directed substantially downward.

Figure 4 is a graph illustrating light output (luminance: y axis) of an exemplary BLDA at an observation or viewing angle range of about -90° to +90° (x axis). The coarseness or banding appears in this embodiment from approximately -45° to +45°. In this embodiment, the pitch, or tip to tip spacing, is in the range from about 0.0508 to 0.254 mm (0.002 to 0.01 inches).

Figure 5 are graphs illustrating light output (lux: y axis) of an exemplary BLDA at viewing angle range of about -70° to +70° from normal (x axis). One graph illustrates the light output across the light source or bulb while the second graph illustrates the light output with the bulb. The data for the graphs are shown in Figure 5.

Figure 6 illustrates an alternative embodiment of a luminaire 11 having an exemplary waveguide 10' and prisms 12' wherein the waveguide and prisms are formed separately and laminated together, for example, with a pressure sensitive adhesive (PSA). The waveguide 10' and prisms 12' can be formed from different materials. In one embodiment, the prisms 12' can be formed from an ultraviolet (UV) curable acrylate thermoset or other suitable materials. Either the waveguide 10' or the prisms 12' (or both) can be colored and/or have printed patterns formed thereon (e.g., logos) to customize the appearance of the luminaire as disclosed in U.S. Application Nos. 09/013,696, now U.S. Patent No. 6,119,751, and 09/170,014, now U.S. Patent No. 6,120,636, filed January 26, 1998 and October 13, 1998, respectively, the teachings of each being incorporated herein in their entirety by reference.

Figure 7 illustrates photometric data from a light system, such as shown in Figure 6. The photodetector was placed about 1.0 meter from the light source. The data represents theoretical and actual measurements taken across the bulb direction, i.e., in the direction of the two-headed arrow 18 of Figure 6.

Figure 8 illustrates another embodiment of a luminaire 19 having mirrors 20 positioned on the ends of the waveguide 10 and above and below the light source 14. The prisms 12' can be integral to the waveguide 10, or alternatively, be laminated to the waveguide 10.

Figure 9 illustrates a luminaire 22 which is similar to the embodiment of Figure 8 but instead of a mirror above the light source 14, a baffle 24 is provided there instead. The baffle 24 can include a white surface which absorbs, diffracts, and scatters light from the light source 14. It is believed that this baffle 24 more uniformly directs the light rays into the waveguide 10 for achieving a more uniform distribution of the light rays in the waveguide.

The table below compares the viewing angle, the measured luminance for the luminaire 19 of Figure 8 and theoretical output for a luminaire having a baffle such as the luminaire 22 of Figure 9. In this embodiment, the pitch of the prisms is about 0.254 mm (0.01 inches).

Angle	Measured Luminance (cd/lux/m^2)	Theoretical with Baffle
180	5.7	16.8458
185	5.1	18.9760
190	5.1	15.2260
195	5.3	8.9539
200	7.6	15.5152
205	13.8	27.0215
210	19.9	37.7291
215	28.2	33.6113
220	37.0	37.6789
225	44.7	44.4249
230	48.9	40.6028
235	47.4	41.2673
240	39.3	35.1872
245	26.1	24.0277
250	10.9	10.6000
255	4.9	4.7000
260	4.6	4.5000
265	4.3	4.2000
270	1.7	1.6000
275	2.8	2.7000
280	5.5	5.4000
285	9.5	8.8104
290	13.0	10.9029

295	15.5	5.3704
300	17.0	8.9190
305	18.7	5.3252
310	21.7	13.4086
315	26.2	18.7654
320	31.8	22.4112
355	38.3	32.3889
330	45.6	43.3254
335	54.5	45.7689
340	53.0	56.6042
345	45.1	49.3210
350	33.0	45.7512
355	21.8	47.1792
0	17.4	41.8723
5	20.2	54.5000
10	30.4	48.0831
15	41.6	46.7072
20	49.6	45.5090
25	5136	47.0374
30	44.0	38.3052
35	36.0	32.6696
40	29.2	21.6011
45	23.8	19.2380
50	19.2	11.7001
55	15.7	6.5985
60	13.4	4.6328

65	12.0	7.7141
70	10.0	9.9115
75	7.5	7.4000
80	7.4	7.3000
85	3.1	3.0000
90	1.9	1.8000
95	3.4	3.3000
100	3.7	3.6000
105	4.0	3.9000
110	7.2	7.1000
115	21.5	21.4000
120	37.2	35.3846
125	46.5	42.8789
130	49.7	45.9643
135	46.7	45.6916
140	38.6	38.2638
145	29.6	36.6630
150	21.1	33.6147
155	14.3	32.8648
160	8.2	13.3652
165	5.5	10.2196
170	5.1	15.5559
175	5.3	18.9760

Sub B2

The linear prisms 12 as described above can be referred to as a one-dimensional structure. That is, the prism structures 12 have peaks and valleys running along one

axis. In alternative embodiments, the prisms 12 can include multiple-dimensional structures, such as two-dimensional structures and three-dimensional structures.

Sub A6 For example, in the embodiment of Figure 6, a two-dimensional prism structure can be constructed by forming a second array of linear prisms perpendicular to the linear prisms 12'. More particularly, a row of linear prisms having peaks 26 and valleys 28 is formed perpendicular to the longitudinal axis of the existing linear prisms 12', i.e., into the paper. Thus, a cross-sectional view taken along line 10-10 is seen in Figure 10. If the prisms are spaced apart, the peaks 26 will have a flat portion as also illustrated in Figure 10. Figure 11 illustrates an enlarged view of the prisms of Figure 6 which illustrates peaks 26 and valleys 28 of the prism arrays. This facilitates controlling of the light rays exiting the waveguide at every angle. In alternative embodiments, the peaks and valleys can be offset at about 60 degree intervals to provide a three-dimensional structure. In further embodiments, the peaks and valleys can be offset at various angles to provide a multiple-dimensional structure.

Ins A7 In alternative embodiments, optical microstructures can be formed on, laminated to, or otherwise provided on sheets, panels, or films for use in luminaires in which control of light distribution is desired. Furthermore, each side of the sheet, panel, or film can have an optical microstructure thereon. These optical microstructures can have tilted prism arrays which alternate orientation along one or more axes.

Sub A8 In any of the disclosed embodiments, multi-faceted prisms can be used, for example, prisms that have more than one slope on a facet. Further, prisms can be used which have curved facets or curved prisms tips and valleys. These features can be used to smooth the resulting light distribution.

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.